

WHAT IS CLAIMED IS:

1. A method for processing a mineral material containing nonferrous base metal, at least a portion of the nonferrous base metal being soluble nonferrous base metal, the method comprising flotation processing of the mineral material, the flotation processing comprising:

5 passing flotation gas through a slurry comprising particles of the mineral material slurried in a flotation liquid, a first portion of the particles rising with the flotation gas through the flotation liquid and being collected in a flotation concentrate enriched in the nonferrous base metal relative to the mineral material, a second portion of the particles being collected as a flotation tail that is depleted in the nonferrous base metal relative to the mineral material, the
10 flotation gas comprising no more than 15 percent oxygen gas;

 dissolving from the mineral material and into the flotation liquid at least a majority of the soluble nonferrous base metal; and

 precipitating in the form of a floatable precipitate at least a majority of the soluble nonferrous base metal dissolved during the dissolving; and

15 collecting at least a majority of the floatable precipitate in the flotation concentrate, wherein the flotation concentrate is enriched in and the flotation tail is depleted in the soluble nonferrous base metal relative to the mineral material.

20 2. The method of Claim 1, wherein the dissolving commences prior to the passing flotation gas through the slurry.

 3. The method of Claim 1, wherein at least a portion of the precipitating occurs during the passing flotation gas through the slurry.

25 4. The method of Claim 1, wherein the flotation gas comprises at least 85 volume percent inert gas.

 5. The method of Claim 4, wherein the flotation gas comprises at least 85 volume percent nitrogen gas.

6. The method of Claim 4, wherein the flotation gas comprises no more than 5 volume percent oxygen gas.

7. The method of Claim 1, wherein the mineral material comprises sulfide mineral material and the flotation concentrate is a sulfide concentrate enriched in the sulfide mineral material relative to the mineral material.

8. The method of Claim 7, wherein the sulfide mineral material comprises one or more iron-containing sulfide mineral serving as a substrate for precipitation of the nonfloatable precipitate, and the flotation concentrate is enriched in the one or more iron-containing sulfide mineral relative to the mineral material.

9. The method of Claim 8, wherein the sulfide mineral material comprises one or more nonferrous base metal sulfide mineral and the flotation concentrate is enriched in the one or more nonferrous base metal sulfide mineral relative to the mineral material.

10. The method of Claim 9, wherein the nonferrous base metal comprises copper and the one or more nonferrous base metal sulfide mineral comprises one or more of chalcopyrite chalcocite, covellite and bornite.

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11. The method of Claim 7, wherein the floatable precipitate comprises the soluble nonferrous base metal in elemental form loaded on the sulfide mineral material.

12. The method of Claim 11, wherein the sulfide mineral material comprises pyrite, during the precipitating the floatable precipitate preferentially deposits on the pyrite, and the flotation concentrate is enriched in the pyrite relative to the mineral material.

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13. The method of Claim 1, wherein during the passing the flotation gas through the slurry, the flotation liquid is at an acidic pH.

14. The method of Claim 13, wherein the acidic pH is no larger than pH 6.5.

15. The method of Claim 14, wherein the acidic pH is in a range of from pH 2 to pH 6.5.

5 16. The method of Claim 15, wherein prior to the dissolving and the precipitating, the flotation liquid comprises in solution a first concentration of the nonferrous base metal of at least 1 gram per liter.

10 17. The method of claim 16, wherein after the precipitating, the flotation liquid comprises in solution a second concentration of the nonferrous base metal that is no larger than one-tenth of the first concentration.

15 18. The method of Claim 1, wherein the mineral material comprises at least 200 ppm of soluble copper that dissolves into the flotation liquid during the dissolving, precipitates in the form of the floatable precipitate during the precipitating and is collected as part of the flotation concentrate during the collecting.

20 19. The method of Claim 1, wherein the mineral material comprises at least 0.1 weight percent of soluble copper that dissolves into the flotation liquid during the dissolving, precipitates in the form of the floatable precipitate during the precipitating, and is collected as part of the flotation concentrate during the collecting.

25 20. The method of Claim 1, wherein the mineral material comprises from 0.1 weight percent to 10 weight percent of the soluble nonferrous base metal that dissolves into the flotation liquid during the dissolving, precipitates in the form of the floatable precipitate during the precipitating and is collected as part of the flotation concentrate during the collecting.

21. The method of Claim 20, wherein the flotation gas comprises no more than 10 volume percent oxygen gas and at least 90 volume percent inert gas.

22. The method of Claim 21, wherein during the passing flotation gas through the slurry, the flotation liquid is at a pH in a range of from pH 2 to pH 6.5.

23. The method of Claim 22, wherein the floatable precipitate comprises the soluble
5 nonferrous base metal in metallic form, and the precipitating comprises depositing the floatable precipitate on sulfide mineral material that is concentrated in the flotation concentrate.

24. The method of Claim 23, wherein the sulfide mineral material comprises one or
more iron-containing sulfide mineral, and the one or more iron-containing sulfide mineral serves
10 as a preferential substrate for the floatable precipitate.

25. The method of Claim 22, wherein:

prior to the dissolving and the precipitating, the flotation liquid contains in solution a first concentration of the nonferrous base metal; and

15 after the dissolving and the precipitating, the flotation liquid contains in solution a second concentration of the nonferrous base metal that is no larger than one-tenth of the first concentration.

26. The method of Claim 25, comprising:

20 prior to the flotation processing, leaching into an aqueous leach liquid a quantity of the nonferrous base metal; and

after the leaching, mixing the leach liquid with the mineral material, the leach liquid forming at least a part of the flotation liquid.

25 27. The method of Claim 1, comprising leaching the flotation concentrate with a leach liquid to dissolve at least a portion of the nonferrous base metal from the flotation concentrate.

28. The method of Claim 27, wherein the leaching comprises pressure oxidizing the
30 flotation concentrate.

29. The method of Claim 27, comprising, after the leaching, removing at least a portion of the nonferrous base metal from the leach solution and preparing a purified product comprising the nonferrous base metal.

5 30. The method of Claim 29, wherein the removing comprises solvent extraction.

31. The method of Claim 1, comprising contacting the mineral material with a lead-containing activator prior to or during the flotation processing.

10 32. The method of Claim 31, comprising contacting the mineral material with a xanthate collector prior to or during the flotation processing.

33. The method of Claim 1, wherein the nonferrous base metal comprises copper.

15 34. The method of Claim 1, wherein the nonferrous base metal comprises one or more of cobalt and cadmium.

35. A method for removing dissolved nonferrous base metal from an aqueous liquid in which the nonferrous base metal is dissolved, the method comprising:

20 contacting the liquid containing the dissolved nonferrous base metal with sulfide mineral material;

during the contacting, precipitating from the liquid at least a portion of the nonferrous base metal and loading onto the sulfide mineral material a precipitate containing at least a portion of the nonferrous base metal precipitated from the solution;

25 during the precipitating, passing a gas through the liquid, the gas comprising no more than 15 volume percent oxygen gas; and

separating from the liquid sulfide mineral material loaded with the precipitate.

36. The method of Claim 35, wherein during the precipitating, the gas comprises at 30 least 90 volume percent inert gas.

37. The method of Claim 35, wherein the separating comprises removing the sulfide mineral material loaded with the precipitate from froth forming at the surface of the liquid during the passing the gas through the liquid.

5 38. The method of Claim 35, wherein the liquid is at an acidic pH in a range of from pH 2 to pH 6.5.

39. A method for recovering nonferrous base metal from a mineral material, the method comprising:

10 leaching nonferrous base metal from the mineral material into an aqueous leach solution; after the leaching, contacting the leach solution with sulfide mineral material while passing a gas through the leach solution, the gas comprising no more than 15 volume percent oxygen gas,

15 during the contacting, at least a majority of the nonferrous base metal leached into the leach solution during the leaching precipitates from the leach solution and forms a precipitate associated with the sulfide mineral material;

separating the sulfide mineral material and the precipitate associated with the sulfide mineral material from the leach solution.

20 40. The method of Claim 39, wherein the sulfide mineral material is a sulfide concentrate.

41. The method of Claim 40, wherein the mineral material is a first mineral material and the sulfide concentrate is a flotation concentrate prepared from a second mineral material.

25 42. The method of Claim 41, wherein:
when introduced into the contacting, the sulfide mineral material is part of an ore material;
during the contacting, the ore material is separated by flotation into a flotation
30 concentrate enriched in sulfide minerals relative to the ore material and a flotation tail depleted in sulfide minerals relative to the ore material; and

the separating comprises collecting the flotation concentrate from froth forming at the top of the leach liquid during the contacting.

43. The method of Claim 39, wherein the leach solution is at a pH of from pH 2 to pH 5 6 during the contacting.

44. The method of Claim 43, wherein the leach solution is at a lower pH during the leaching than during the contacting, and the method comprises adjusting the pH of the leach solution between the leaching and the contacting.

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45. The method of Claim 39, wherein the nonferrous base metal comprises copper.

46. The method of Claim 45, wherein:

the leach solution has a first concentration of the nonferrous base metal after the leaching 15 and prior to the contacting; and

the leach solution has a second concentration of the dissolved nonferrous base metal following the contacting, the second concentration being no larger than one-tenth of the first concentration.

20 47. The method of Claim 46, wherein the first concentration is larger than 1 gram per liter of the nonferrous base metal in the leach solution.